REMARKS

I. Introduction

By the present Amendment, claim 18 has been amended. No claims have been added or cancelled. Accordingly, claims 1-6, 8-10, and 18 remain pending in the application. Claims 1 and 18 are independent.

II. Office Action Summary

In the Office Action of December 8, 2009, claims 1, 5, 6, 8, and 18 were rejected under 35 USC §103(a) as being unpatentable over U.S. Patent No. 5,910,118 issued to Kanda et al. ("Kanda") in view of U.S. Patent No. 5,474,073 issued to Schwartz et al., ("Schwartz"), and further in view of U.S. Patent Application No. 2004/0068188 to Robinson, and still further in view of U.S. Patent No. 5,769,079 issued to Hossack. Claims 2 and 3 were rejected under 35 USC §103(a) as being unpatentable over Kanda in view of Schwartz and Robinson, and further in view of U.S. Patent No. 4,671,293 issued to Shaulov. Claims 9 and 10 were rejected under 35 USC §103(a) as being unpatentable over Kanda in view of Schwartz and Robinson, and further in view of U.S. Patent No. 4,932,414 issued to Coleman et al. ("Coleman"). These rejections are respectfully traversed.

III. Rejections under 35 USC §103

Claims 1, 5, 6, 8, and 18 were rejected under 35 USC §103(a) as being unpatentable over Kanda in view of Schwartz and Robinson, and further in view of Hossack. Regarding this rejection, the Office Action alleges that Kanda discloses a Doppler detector for measuring velocity, blood flow, and motion which includes an ultrasound probe that has an array of piezoelectric transducers arranged at the tip

thereof. The transducer allegedly contains a plurality of piezoelectric elements that are arranged in an array and in a scanning direction. The Office Action indicates that the apparatus of Kanda includes means for removing a clutter component, means for extracting information representing blood flow passing the cross section based on the Doppler signal, means for displaying the extracted information, removing means to subtract a constant value corresponding to the clutter component, and estimating means and calculation means. The Office Action further indicates that Kanda teaches transmitting an ultrasound signal a plurality of times in each scanning direction composing a cross-section to be imaged using extracted echo signals to estimate motion of states of blood flows, and producing two-dimensional tomographic images based on the estimated information. The Office Action further indicates that Kanda discloses the use of a moving target indication filter color flow mapping and reconstruction of a CFM image to become a three-dimensional volume data, and temporal reception echoes in the three-dimensional volume data for the same pixel position in a scanned cross section.

The Office Action admits that Kanda fails to specifically mention first and second transducers, and detection of three-dimensional motion in an object. Nonetheless, the Office Action indicates that Kanda teaches an array of transducers that comprises a plurality of piezoelectric elements to transmit waves and acquire two-dimensional cross-section images, and that one skilled in the art would have known that a first and second transducer can be picked and designated as such from the array of transducers. Robinson is relied upon for disclosing multiple transducer arrays that can be used as first and/or second transducers. Schwartz is relied upon for disclosing three-dimensional presentation of the motion or fluid flow. The Office Action also indicates that Schwartz utilizes Doppler power which is well known for

detecting/measuring velocity flow, as well as the use of transducer elements to alternately scan the object and allow them to cross over each other. Hossack is relied upon for teaching reconstruction and display of multiple 2D into 3D of velocity flow. The Office Action concludes that it would have been obvious to combine the teachings of Kanda, Schwartz, Robinson, and Hossack to arrive at the claimed invention. Applicants respectfully disagree.

As amended, independent claim 1 defines an ultrasonic motion detecting device that comprises:

> first and second ultrasonic transducers having piezoelectric elements arranged in an array, which transmit ultrasonic waves to an object and acquire reflection signals from the object;
>
> a motion detection unit that extracts an estimation region which is used for estimating a motion of the object from the reflection signals that are acquired by the first and second ultrasonic transducers, and detects a three-dimensional motion of the object within the estimation region; and
>
> an image display unit that displays the three-dimensional motion within the estimation region,
>
> wherein ultrasonic wave scanning surfaces due to the first and second ultrasonic transducers cross over each other, and
>
> wherein the motion detection unit detects projected components that are detected from a plurality of first two-dimensional cross-section images of the object which are obtained from the first ultrasonic transducer and a plurality of second two-dimensional cross-section images of the object which are obtained from the second ultrasonic transducer to produce velocity components of the three-dimensional motion, and constructs the three-dimensional motion on the basis of the first two-dimensional cross-section image, the second two-dimensional cross-section image and the projected components.

According to independent claim 1, the ultrasonic motion detecting device includes first and second ultrasonic transducers having piezoelectric elements arranged in an array in order to transmit ultrasonic waves to an object and acquire

reflection signals from the object. A motion detector unit is used to extract and estimation region that is used for estimating the motion of the object from the reflection signals acquired by the first and second ultrasonic transducers, and detecting a three-dimensional motion of the object within the estimation region. An image display unit is provided for displaying the three-dimensional motion within the estimation region. According to independent claim 1, the ultrasonic wave scanning surfaces due to the first and second ultrasonic transducers cross over each other. Furthermore, the motion detection unit detects projected components that are detected from a plurality of first dimensional cross-section images of the object obtained from the first ultrasonic transducer and a plurality of second two-dimensional cross-section images of the object obtained from the second ultrasonic transducer. The motion detection unit then produces velocity components of the three-dimensional motion and constructs the three-dimensional motion based on the first two-dimensional cross-section image, the second two-dimensional cross-section image, and the projected components.

According to the present invention, the motion estimation of the object is conducted on the intersection planes of the two scanning surfaces, and the velocity components of the three-dimensional motion of the objects are detected. The two-dimensional information of the intersection planes are used to obtain the velocity components of the three-dimensional motion of the object without noise or the influence of minute fluctuations of signal. See paragraph [0065] of the published application.

Kanda discloses an ultrasound imaging apparatus wherein a Doppler signal is detected from a group of echo signals consisting of a train of sequential Doppler data for each spatial sample position in each scanning direction. The amount of

instantaneous changes in the phase of clutter components in the Doppler signal is estimated as representative of the clutter component occurring due to reflection of the ultrasound signal from an organ.

According to Kanda, the MTI filter is used to assist in distinguishing echoes reflected from blood flows of extremely low velocities from clutter components in a steady and accurate manner. Kanda separates a clutter component and a blood flow component based on the Doppler signal, or phase information, after an orthogonal detection. The clutter component, however, corresponds to an echo of the ultrasound signal from the organ. In order to eliminate the clutter component, the amount of instantaneous changes in the phase of the clutter component included in each Doppler signal is estimated, the phase of each Doppler signal is corrected using the estimated amount, and a constant value corresponding to the clutter component is subtracted from the phase-corrected Doppler signal. Kanda explicitly discloses that various organs are in motion or tend to move based on the effects of heartbeat, motion of surrounding organs, breathing motions performed by the patient, and reactions to movement by the examining operator or physician. Thus, by distinguishing and separating these clutter components, Kanda actively removes the organs in order to only display the blood flow images. See column 2, lines 53-64. Kanda clearly treats echoes reflected from organs as noise and eliminates them. It is therefore not possible to detect object (organ/body) motion because echoes reflected from the organs are discarded.

Furthermore, as illustrated in Fig. 3, Kanda's apparatus utilizes two-dimensional information for each pixel. This is readily apparent because the number of pixels represents one dimension of the three-dimensional space. In particular, Kanda indicates that the first direction (L) represents the number of scanning lines,

the second direction (M) represents the number of pixels, and the third direction (N) represents the number of data at each pixel. The Doppler data is then aligned in a time sequential manner in order to provide information corresponding to the dynamics of blood flow for each pixel. See column 6, lines 56-65.

Contrary to the assertions made in the Office Action, the apparatus of Kanda is not capable of detecting three-dimensional body motion using Doppler signals obtained from a plurality of ultrasound transmissions in the same scanning direction. Rather, Kanda's use of Doppler signals only allows detection of corrected blood velocity in the transmitting end receiving direction of the ultrasound. Kanda's apparatus is also incapable of detecting blood velocity in a rectangular direction of the ultrasound.

Schwartz discloses an ultrasonic diagnostic system for producing three-dimensional ultrasonic image displays utilizing power Doppler signal information. According to Schwartz, the power Doppler signal information is displayed in the absence of B-mode information in order to reduce image clutter and provide three-dimensional image segmentation. Schwartz also utilizes a scanning technique to acquire diagnostic three-dimensional ultrasonic images through manual hand scanning of a patient, and without the need for specialty scanning mechanisms and/or devices. Contrary to the present invention, however, Schwartz provides no disclosure or suggestion for taking body motions into consideration when generating the three-dimensional images. Schwartz fails to disclose detection of the velocity components of three-dimensional motion of an object, such as an organ, particularly based on the use of multiple two-dimensional cross-section images.

Robinson discloses a synthetic focus ultrasound system which alternates between synthetic focus acquisition and conventional focused beam acquisition,

thereby making it possible to acquire and display harmonic images. Signals from sub-apertures viewing the image field from different directions are combined in order to reduce speckle artifacts in the synthetic focused ultrasound images. While Robinson appears to disclose the use of two transducer arrays, there is no disclosure or suggestion for consideration of body motion when reconstructing the image. Robinson fails to disclose detection of the velocity components of three-dimensional motion of an object, such as an organ, particularly based on the use of multiple two-dimensional cross-section images.

Hossack discloses an apparatus for determining quantitative measurements using Doppler ultrasound. The apparatus includes an ultrasonic probe which has two transducer arrays oriented at right angles and spaced apart from each other. The first array measures multiple Doppler parameters such as velocity at respective regions within a cross-section of a blood vessel, while the second array measures Doppler parameters at one of the first regions. The first and second Doppler parameters for the same point are used to correct the first apparent Doppler parameters to nearly equal the true velocity or energy. Hossack only appears to disclose techniques for reconstructing and displaying 2D and 3D images of a velocity flow. There is no disclosure or suggestion for considering body motion when reconstructing 3D images, and no disclosure or suggestion for detecting the velocity components of three-dimensional motion of an object, such as an organ, particularly based on the use of multiple two-dimensional cross-section images.

According to the present invention, however, motion estimation of an object is performed on respective crossed plane images of two scanning surfaces while detecting projected components in order to identify velocity components of the three-

dimensional motion of the object. Thus, motion estimation of the object is performed on the intersection planes of the two scanning surfaces, and the velocity components of the three-dimensional motion of the objects are detected. This allows the use of two-dimensional information of the intersection planes in order to obtain velocity components of the three-dimensional motion of the object without any noise or fluctuations of the signal. Kanda, for example, is incapable of detecting three-dimensional body motion because only Doppler signals obtained from a plurality of ultrasound transmissions and receptions in the same scanning direction are used. Kanda is also silent on detecting body motion when constructing the images.

All of the cited references fail to provide any disclosure or suggestion for features recited in independent claim 1, such as:

> wherein the motion detection unit detects projected components that are detected from a plurality of first two-dimensional cross-section images of the object which are obtained from the first ultrasonic transducer and a plurality of second two-dimensional cross-section images of the object which are obtained from the second ultrasonic transducer to produce velocity components of the three-dimensional motion, and constructs the three-dimensional motion on the basis of the first two-dimensional cross-section image, the second two-dimensional cross-section image and the projected components.

It is therefore respectfully submitted that independent claim 1 is allowable over the art of record.

Claims 2-6 and 8-10 depend from independent claim 1, and are therefore believed allowable for at least the reasons set forth above with respect to independent claim 1. In addition, these claims each introduce novel elements that independently render them patentable over the art of record.

Independent claim 18 is newly presented and defines an ultrasonic motion detecting device that comprises:

> first and second ultrasonic transducers, which transmit ultrasonic waves to an object and acquire reflection signals from the object; and
>
> a motion detection unit that extracts an estimation region which is used for estimating a motion of the object from the reflection signals that are acquired by the first and second ultrasonic transducers, and detects a three-dimensional motion of the object within the estimation region;
>
> wherein ultrasonic wave scanning surfaces due to the first and second ultrasonic transducers cross over each other, and
>
> wherein the motion detection unit detects velocity components of the three-dimensional motion of the object based on a first two-dimensional cross-section image of the object obtained from the first ultrasonic transducer and a second two-dimensional cross-section image of the object obtained from the second ultrasonic transducer, and constructs the three-dimensional motion of the object to be displayed in an image display unit in accordance with the velocity components of the three-dimensional motion of the object.

According to at least one feature of independent claim 18, the motion detection unit detects velocity components of the three-dimensional motion of the object based on a first two-dimensional cross-section image of the object obtained from the first ultrasonic transducer and a second two-dimensional cross-section image of the object obtained from the second ultrasonic transducer. The motion detection unit then constructs the three-dimensional motion of the object to be displayed in an image display unit in accordance with the velocity components of the three-dimensional motion of the object. As previously discussed, the art of record fails to provide any disclosure or suggestion for detecting velocity components of the three-dimensional motion of the object.

It is therefore respectfully submitted that independent claim 18 is allowable over the art of record.

IV. Conclusion

For the reasons stated above, it is respectfully submitted that all of the pending claims are now in condition for allowance. Therefore, the issuance of a Notice of Allowance is believed in order, and courteously solicited.

If the Examiner believes that there are any matters which can be resolved by way of either a personal or telephone interview, the Examiner is invited to contact Applicants' undersigned attorney at the number indicated below.

AUTHORIZATION

Applicants request any shortage or excess in fees in connection with the filing of this paper, including extension of time fees, and for which no other form of payment is offered, be charged or credited to Deposit Account No. 01-2135 (Case: 520.46263X00).

Respectfully submitted,
ANTONELLI, TERRY, STOUT & KRAUS, LLP.

/Leonid D. Thenor/
Leonid D. Thenor
Registration No. 39,397

LDT/vvr
1300 N. Seventeenth Street
Suite 1800
Arlington, Virginia 22209
Tel: 703-312-6600
Fax: 703-312-6666

Dated: March 8, 2010